

The tau neutrino magnetic moment

Reinhard Schwienhorst
University of Minnesota

Long report
E872 phone meeting, 4/23/99

Outline

- Physics reminder
- Analysis:
 - Cuts
 - Monte Carlo Analysis
 - Data Analysis
 - Example: event energy
- Outlook
- Conclusion

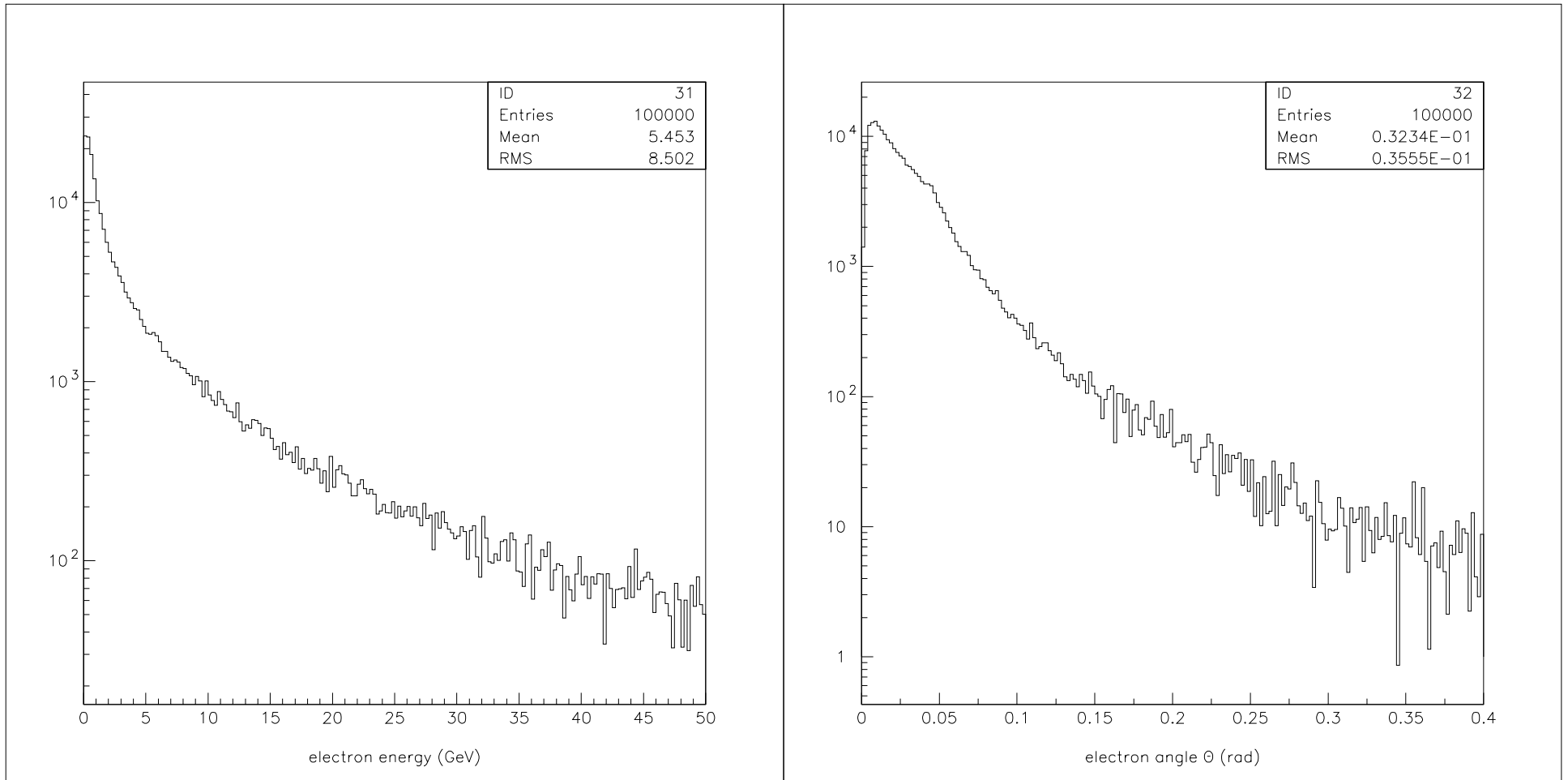
Physics reminder

- Neutrino-electron scattering
 - no hadronic activity in the event
 - small forward angle θ
- magnetic moment interaction
 - cross section

$$\frac{d\sigma}{dT} \propto \mu_\nu^2 \left(\frac{E_\nu}{T} - 1 \right)$$

- μ_ν : neutrino magnetic moment
- E_ν : neutrino energy
- T : electron kinetic energy

Electron energy and angle



Expected event yield

- If $\mu_v = 5.4 \times 10^{-7} \mu_B$ (the current limit):
 - with an electron energy cutoff at 5GeV
 - current neutrino event sample
 - expect $\approx 10 \nu_\tau$ magnetic moment interactions
 - (compared to $\approx 40 \nu_\tau$ CC interaction)
 - with an electron energy cutoff at 0.5GeV
 - .nustrip files, single track events
 - expect $\approx 30 \nu_\tau$ magnetic moment interactions
 - with an electron energy cutoff at 10MeV
 - emulsion analysis
 - expect $\approx 80 \nu_\tau$ magnetic moment interactions
 - we must scan at least 1/3 of the emulsion to improve the sensitivity

Analysis outline

- Make cuts that are optimized for magnetic moment events
- cross-check using ν_μ CC events (data and MC)
 - easy to find
- apply to neutrino candidate events
 - apply to MC of neutrino candidates
 - find the expected number of events
- apply to .nustrip files
 - find (almost) all candidate events

Cuts

- Remove hadrons:
- Muon ID
 - remove muons and hadrons
 - watch out for noise
 - require <2 MID hits (sum over all tracks)
- EMCAL
 - require $E_{\text{EMCAL}} < 20\text{GeV}$
 - require for each track with $P > 4\text{GeV}$ that $E_{\text{EMCAL}} < P/2$ for blocks within 0.2m of the track
 - check a rectangle of $x < 0.7\text{m}$ and $y < 0.2\text{m}$ distance to the vertex:
 - require at least 50% of the EMCAL energy to be inside the rectangle
 - require the energy outside the rectangle to be less than 1GeV

Cuts (II)

- SF system
 - remove events with large pulseheight hits in consecutive planes of the same view
 - remove events with tracks that pass through a module (linked tracks)
- total event energy
 - use the SF hits and the EMCAL to determine the total event energy
 - require the total event energy to be $<20\text{GeV}$
- single track events
 - require negative momentum
 - require showering in the emulsion
 - require angle $<0.2\text{rad}$

Monte Carlo analysis

- So far only period 4
- Trigger efficiency 65% for $T > 0.5 \text{ GeV}$ magnetic moment interactions (ν_τ)
- The cuts remove 35% of the magnetic moment interactions
 - each cut is tuned to remove $\approx 5\%$

Neutrino candidate analysis

- Advantage:
 - small sample
- Disadvantage:
 - total energy $>5\text{GeV}$
- Result for period 4:
 - three candidates
 - sent to Nagoya for emulsion scanning
 - expect ten events at the current limit ($\mu_{\nu}=5.4\times 10^{-7}\mu_{\text{B}}$)

.nustrip analysis

- $\approx 150,000$ events in the .nustrip files
- the cuts reduce it to $\approx 10,000$ events (6%)
- more work has to be done
 - ideas:
 - distinguish EM showers from hadron showers (width,...)
 - require a straight track to come from the vertex
 - visual check to remove straight hadron tracks in the SF
 - ...

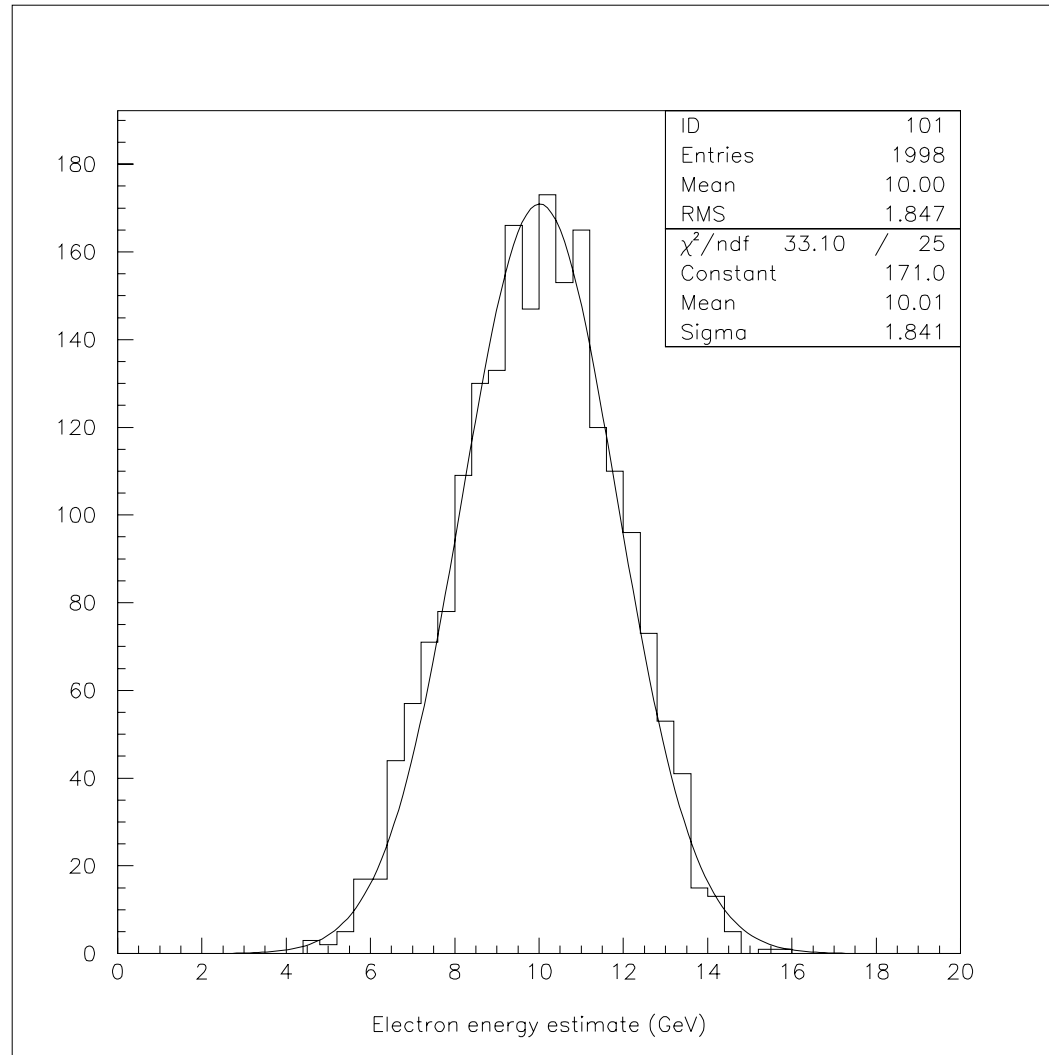
Example: event energy

- Generate single 10GeV electrons with the MC
 - reconstruct the electron energy
 - find # of hits behind each SF module, # of VC hits, EMCAL energy
 - assign weight to each number and add to get the total visible energy
- generate μ CC neutrino events
 - reconstruct the muon momentum
 - find the hadronic energy (number of hits)
 - compare to data

Plots:

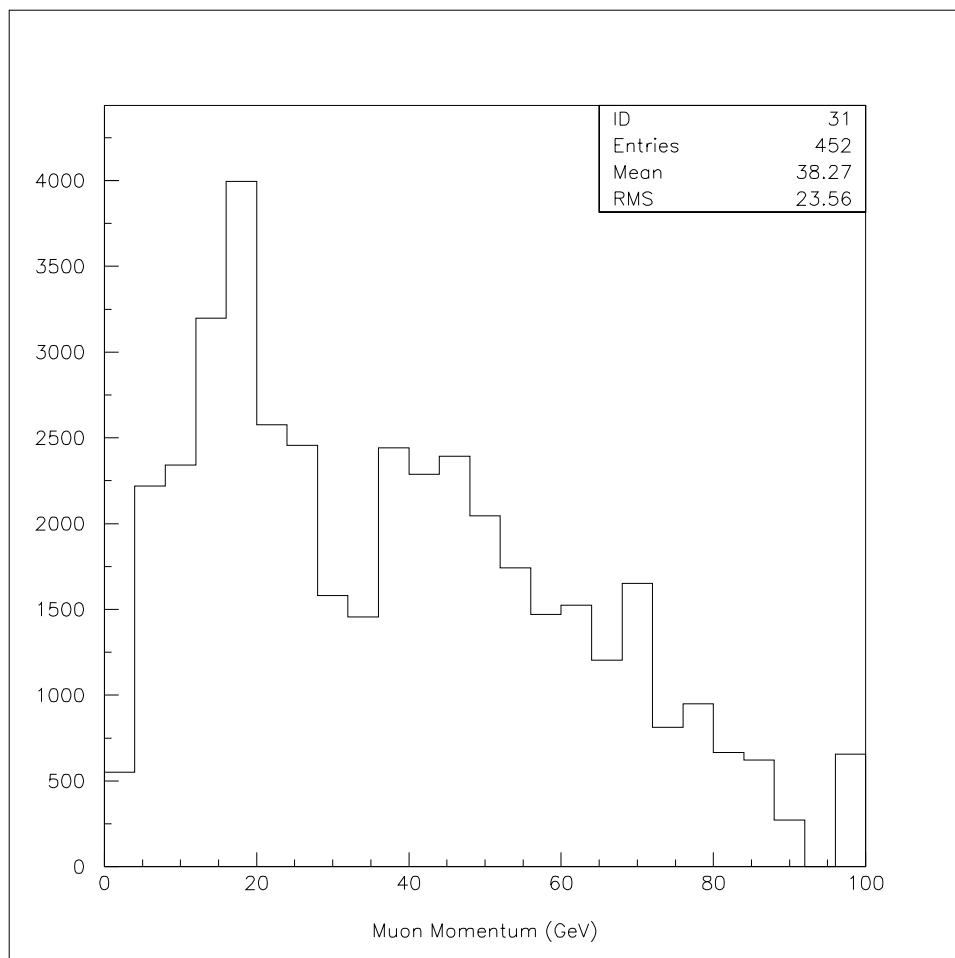
- Reconstructed electron energy
 - MC, 10GeV electrons, period 4 configuration, target: 01111
 - width is 18.5%
- Reconstructed hadron energy
 - μ CC events, including nonprompt ν s, require μ , $0 < P_\mu < 100\text{GeV}$
 - plot P_μ , hadronic energy, SF hits, VC hits
- Reconstructed neutrino energy
 - μ CC events, including nonprompt ν s, require μ , $0 < P_\mu < 100\text{GeV}$
 - compare MC and period 4 data
 - plot $(\text{estimate} - \text{true}) / \text{true}$
 - width is 25%

Reconstructed energy for 10GeV electrons

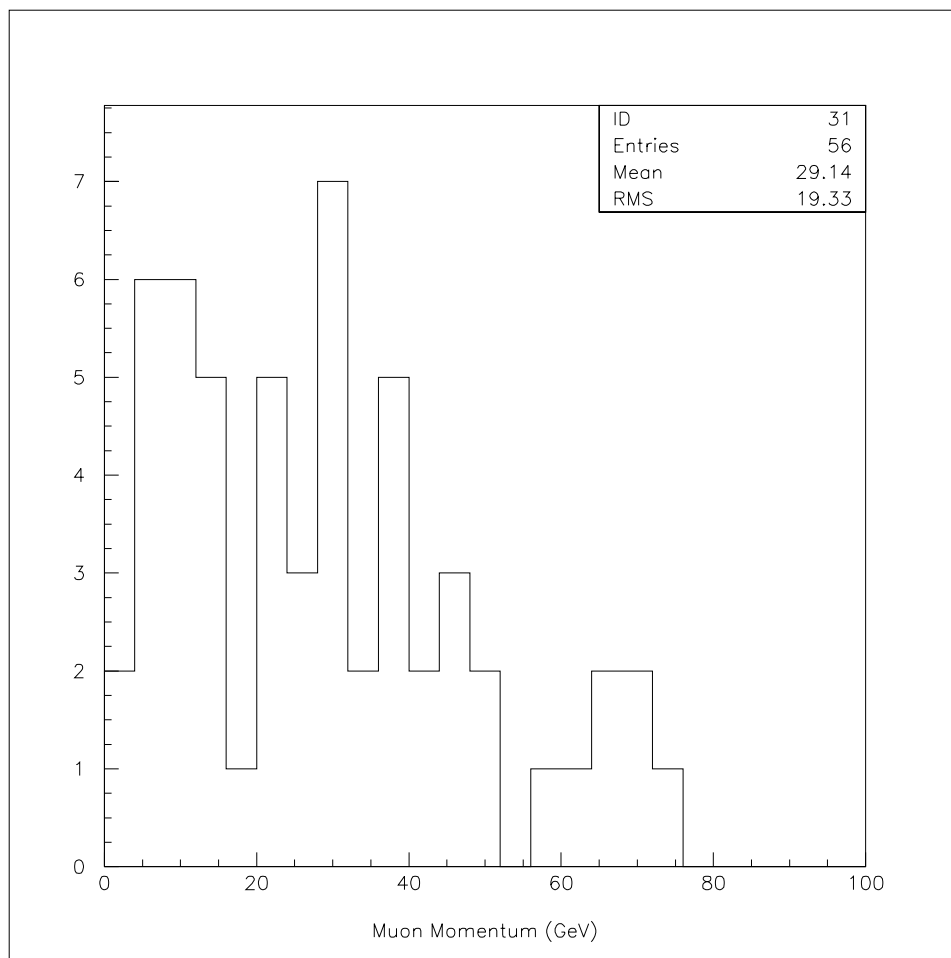


Method: add up all hits in the SF, VC. Add EMCAL energy

Muon momentum comparison

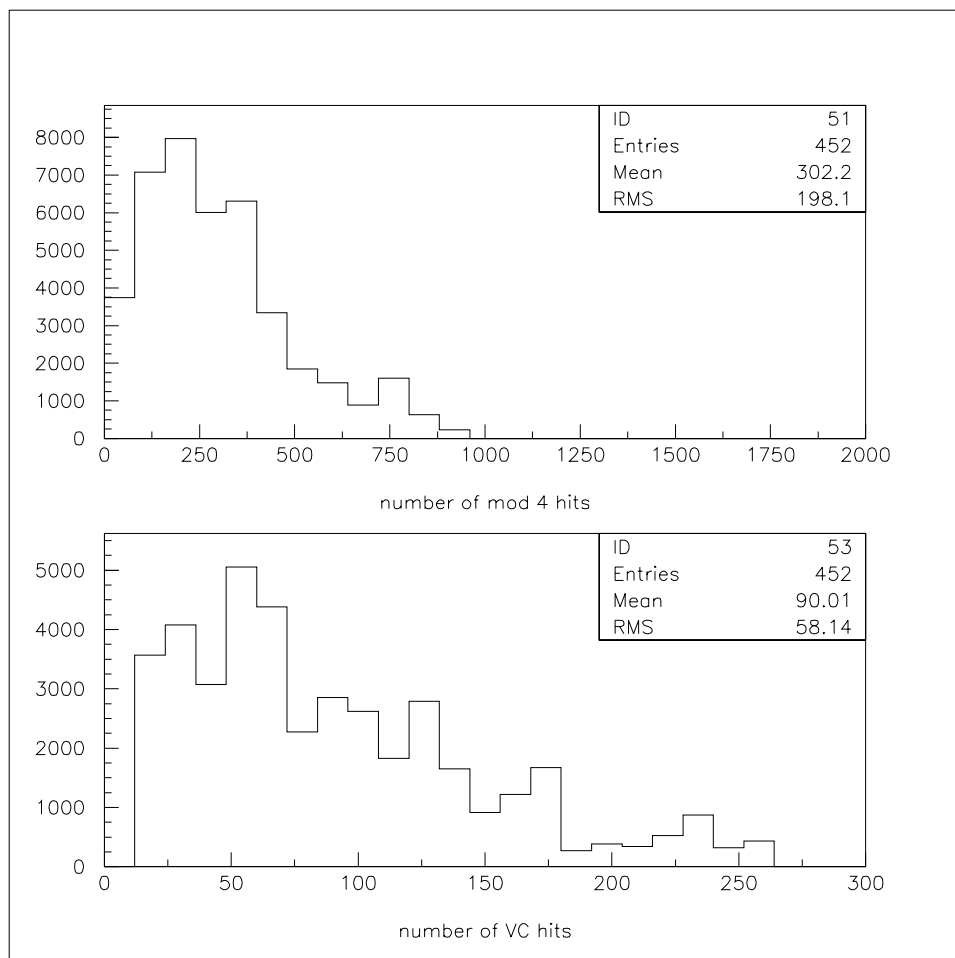


MC

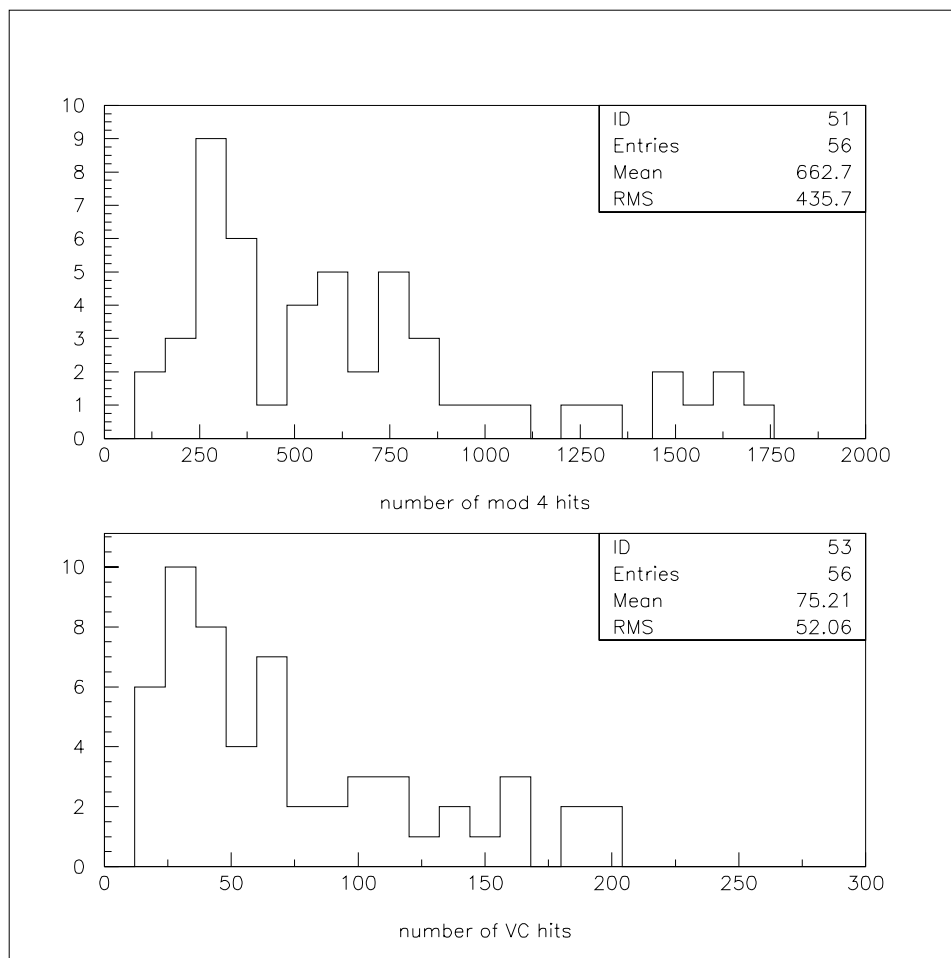


Period 4 data

of hits comparison: module 4 and VC



MC

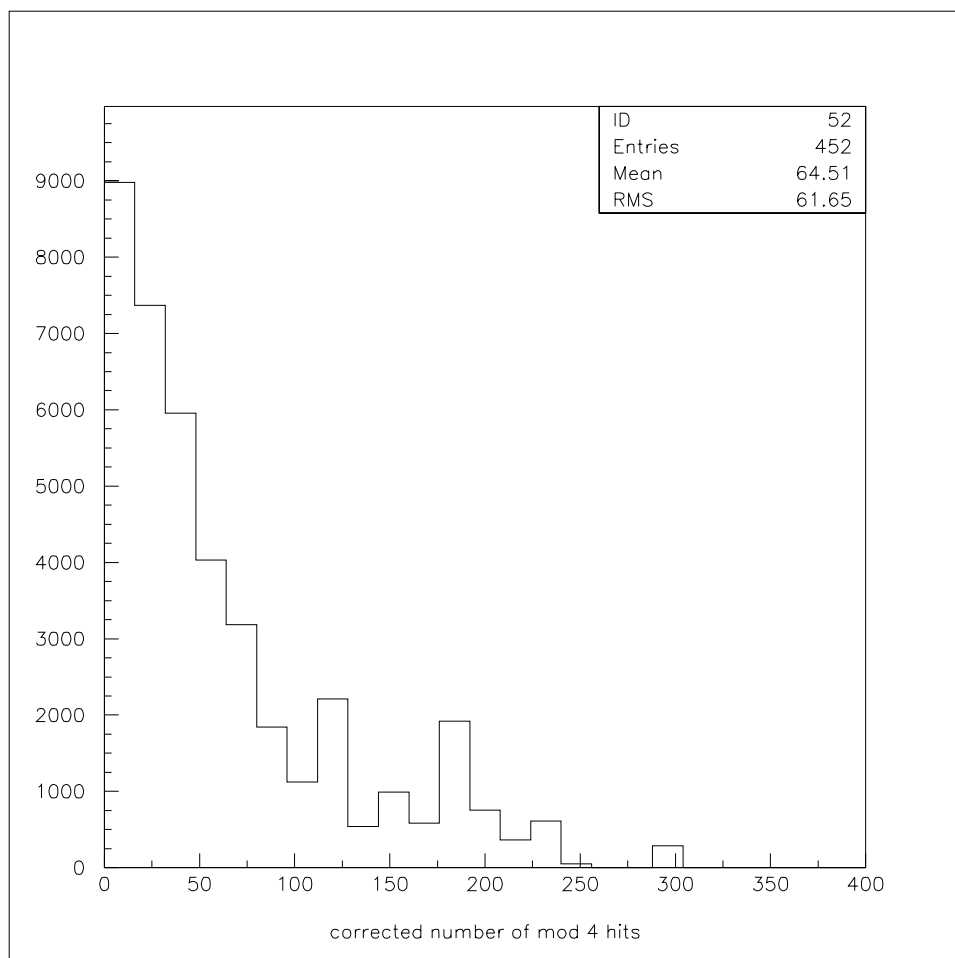


Period 4 data

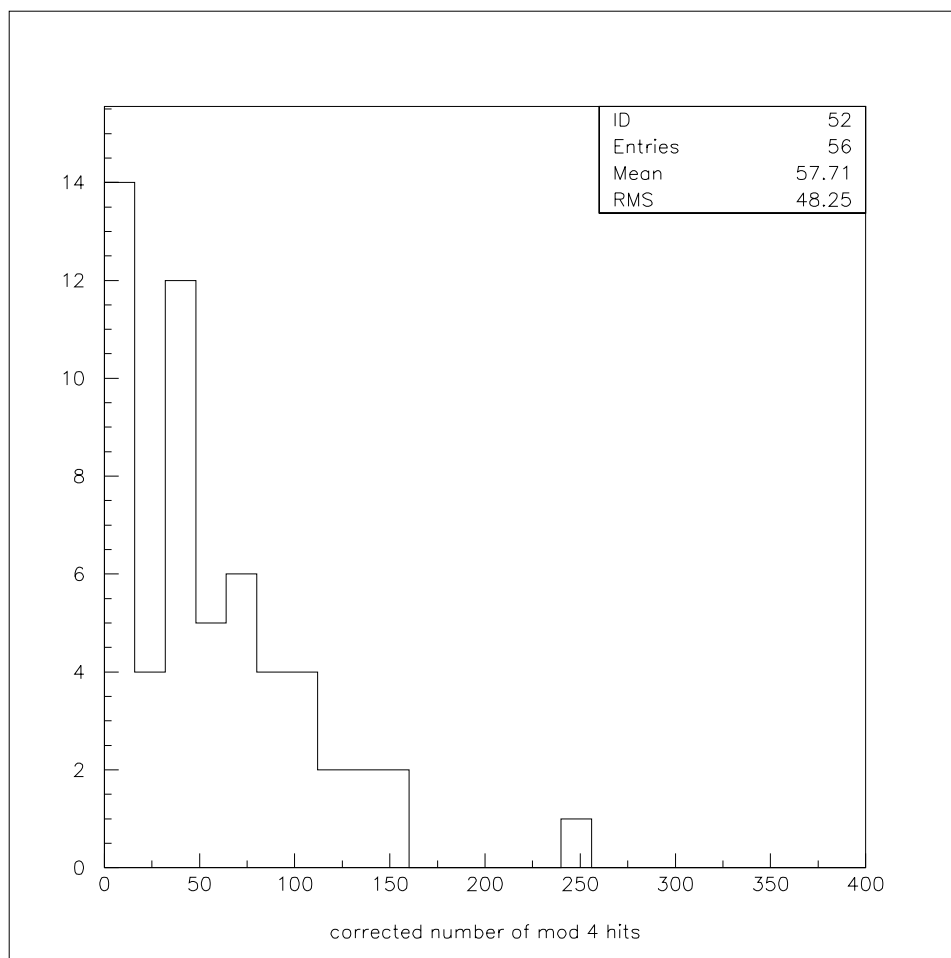
Energy estimate

- Problem:
 - counting SF hits under-estimates the hadronic energy
- Cause:
 - the number of hits in the SF system is not accurate
 - simulation of hadron showers
 - small momentum, large angle hadrons
 - simulation of the IIT-SF system
- Solution:
 - only consider hits within a distance of 1cm to the vertex

of SF module 4 hits within 1cm of the vertex

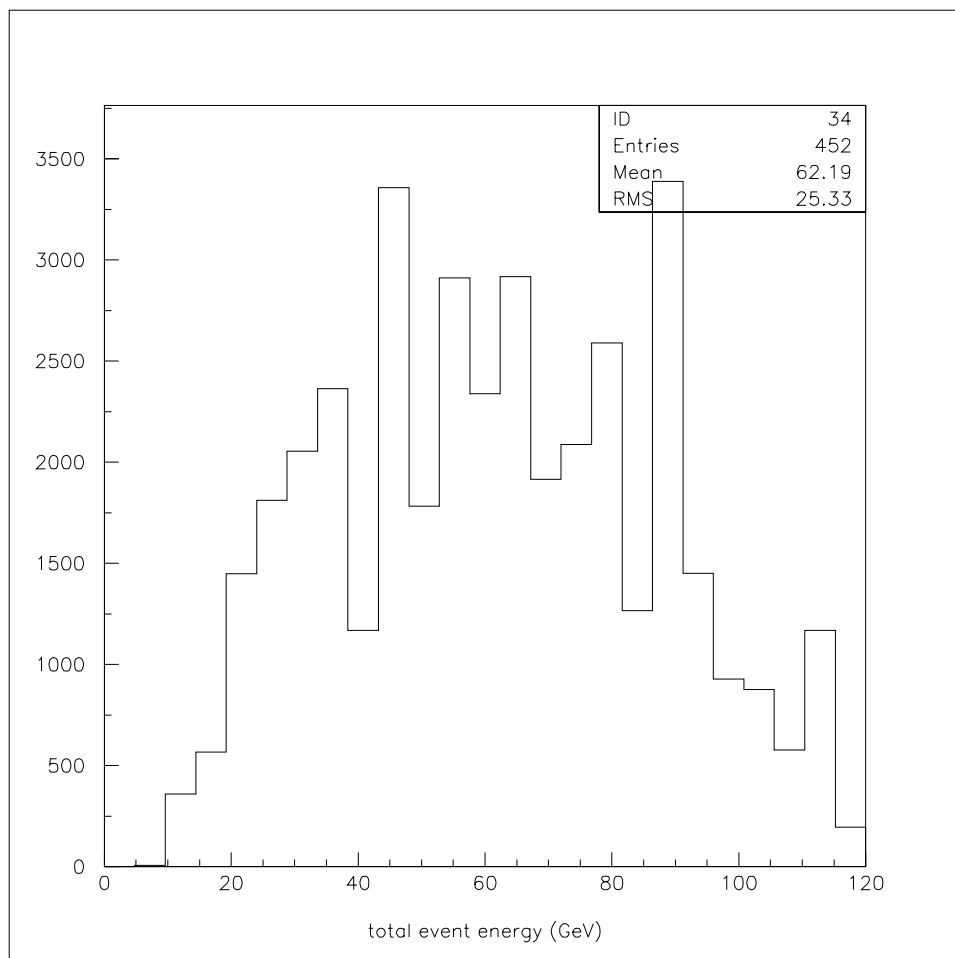


MC

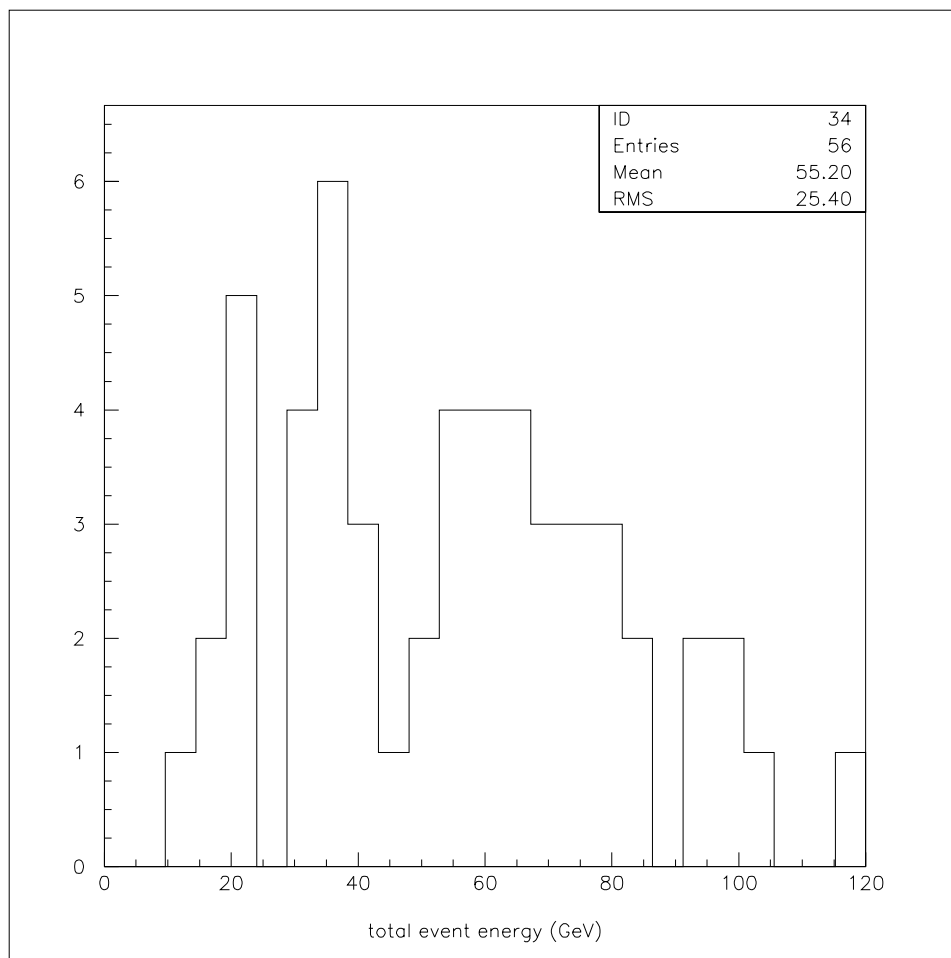


data

Neutrino energy estimate, μ CC events corrected analysis

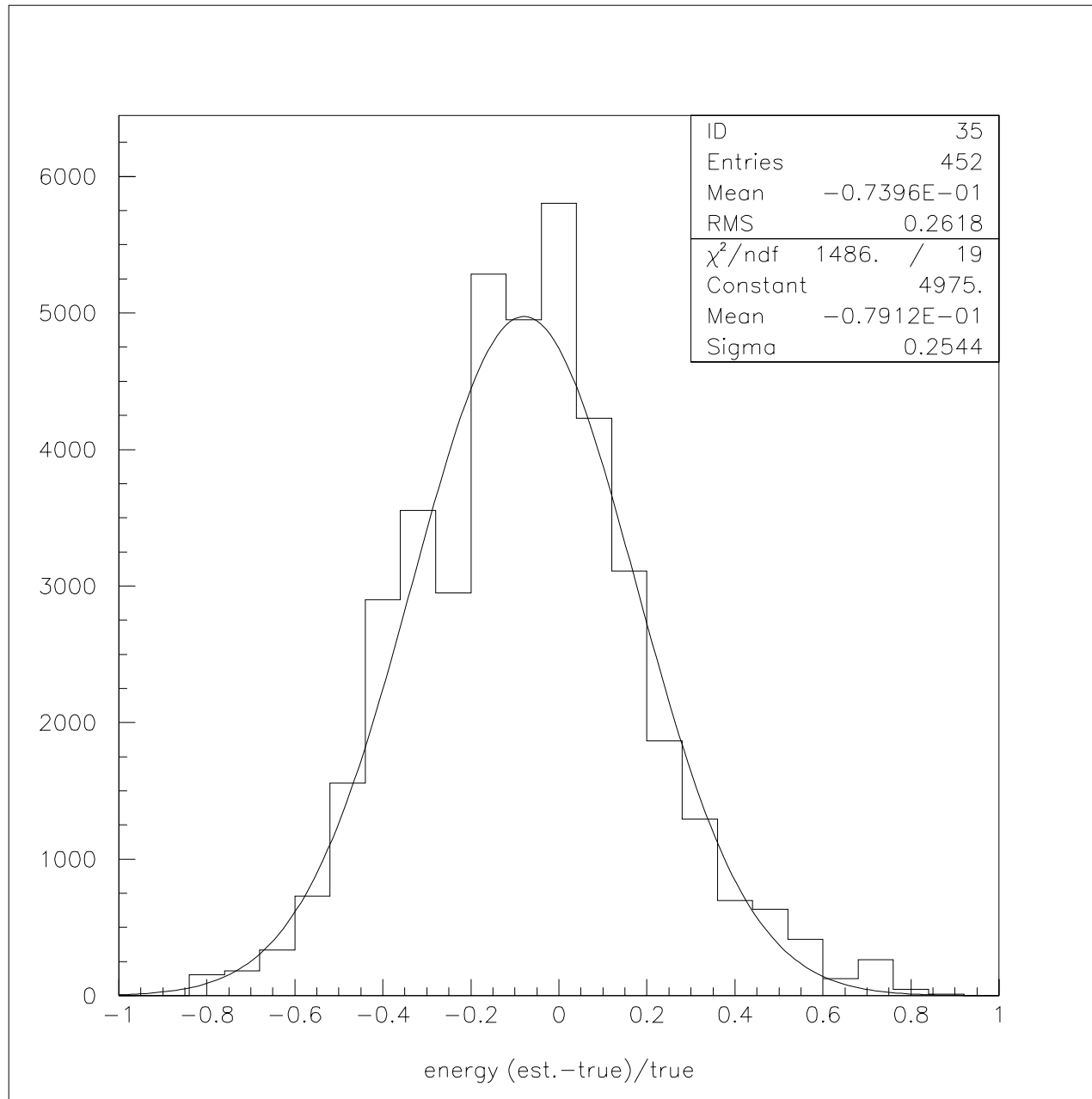


MC



Period 4 data

Corrected neutrino energy estimate, accuracy



Outlook for the next two months

- Finish .nustrip analysis for period 4
- Analyze MC events for periods 1,2,3
- Analyze data for period 1,2,3
 - neutrino candidates and .nustrip files
- Continue writing thesis
 - complete detector chapter
 - write analysis chapter
- Visit Nagoya in June
 - get an update on the events I sent to Japan
 - discuss emulsion search

Conclusion

- The analysis is still in progress
- I have sent three events to Nagoya
 - this implies: $\mu_{\nu\tau} < 5 \times 10^{-7} \mu_B$
- Searching for event candidates in the .nustrip files will give the best limit
- The Emulsion/SF system is a good calorimeter
- The analysis of μ CC events shows a deviation from the current MC
 - μ momentum and total event energy
 - the apparent neutrino spectrum has a smaller mean energy